Using Benchmarking to Minimize Common DOE Waste Streams

Volume I. Methodology and Liquid Photographic Waste

Prepared for
U.S. Department of Energy
Environmental Restoration and Waste Management
Office of Waste Management
Waste Minimization Division

Prepared by
Victoria Levin
Environmentally Conscious Life Cycle Systems Department
Sandia National Laboratories
Albuquerque, NM 87185 and Livermore, California 94550

April 10, 1994

SAND 93-3992
Unlimited Release
Printed April 1994

Distribution
Category UC-600

USING BENCHMARKING TO MINIMIZE COMMON DOE WASTE STREAMS
Volume I.
Methodology and Liquid Photographic Waste

Prepared for
U.S. Department of Energy
Environmental Restoration and Waste Management
Office of Waste Management
Waste Minimization Division

Prepared by
Victoria Levin
Environmentally Conscious Life Cycle Systems Department
Sandia National Laboratories
Albuquerque, NM 87185 and Livermore, California 94550

This work was supported by the U.S. DOE under contract DE-AC04-94AL85000.

Abstract

Finding innovative ways to reduce waste streams generated at Department of Energy (DOE) sites by 50% by the year 2000 is a challenge for DOE's waste minimization efforts. This report examines the usefulness of benchmarking as a waste minimization tool, specifically regarding common waste streams at DOE sites. A team of process experts from a variety of sites, a project leader, and benchmarking consultants completed the project with management support provided by the Waste Minimization Division EM-352. Using a 12-step benchmarking process, the team examined current waste minimization processes for liquid photographic waste used at their sites and used telephone and written questionnaires to find "best-in-class" industry partners willing to share information about their best waste minimization techniques and technologies through a site visit. Eastman Kodak Co., and Johnson Space Center/National Aeronautics and Space Administration (NASA) agreed to be partners. The site visits yielded strategies for source reduction, recycle/recovery of components, regeneration/reuse of solutions, and treatment of residuals, as well as best management practices. An additional benefit of the work was the opportunity for DOE process experts to network and exchange ideas with their peers at similar sites.

ACKNOWLEDGMENTS

This report represents the efforts of many participants who shared their talents, time, and resources to further DOE's waste minimization efforts. We thank:

Industry partners and their representatives:

- Eastman Kodak Co., Rochester, NY; William M. Reed, Environmental Coordinator
- Johnson Space Center/NASA, Houston, TX; Rick Slater, Photography Technologist

DOE sponsors:

- Kent Hancock and Ker-Chi Chang at DOE EM-352, and Oren Critchfield at DOE/AL
- DOE support staff Patricia Robinson, Paul Deltete, and Troy Eshleman

DOE process experts:

Liquid Photographic Waste Process Experts:

- Will Desmare, Chemical and Environmental Engineer, Pantex-Mason & Hangar, Amarillo, TX
- Robert A. Meibaum, Department Manager, EG&G/EM Remote Sensing Laboratory, Las Vegas, NV
- Dan Ostergaard, Photography Technologist, Boeing Computer Services, Richland, VA
- William P. Tasko, Photographic Scientist, EG&G/EM Remote Sensing Laboratory, Las Vegas, NV
- Paul Van Dyke, Department Manager, SNL/CA, Livermore, CA

Waste Motor Oil Process Experts:

- James Bennett, Waste Minimization Coordinator, Environmental Office, MMES/Y-12, Oak Ridge, TN
- Gary Bowling, Maintenance Supervisor, MMES/Y-12, Oak Ridge, TN
- Dave Dahlquist, Group Environmental Coordinator, EG&G INEL, Idaho Falls, ID
- Danny Gonzales, Fleet Operations Superintendent, REECO, Las Vegas, NV
- Bill Rose, Project Manager for the motor pool, SNL/NM, Albuquerque, NM
- Reggie Tibbets, Maintenance Supervisor, SNL/NM, Albuquerque, NM

Sandia National Laboratories Process Improvement/Benchmarking Department facilitators:

- Lynn Ritchie
- Ken Ronquillo
- Teresa Torres

Executive Summary

The Mission

Finding innovative ways to reduce waste streams generated at DOE sites by 50% by the year 2000 is a challenge for DOE's waste minimization efforts.

Project Focus

Sponsored by the DOE's Waste Minimization Division EM-352, this project focused on identifying common waste streams throughout DOE, examining waste minimization technologies that have been used successfully by companies or organizations other than DOE, and providing this information to affected sites within DOE. Benchmarking was the methodology for analyzing the internal processes and seeking industry partners that have successfully improved their waste minimization processes.

Report Purpose

This report
1. serves as a blueprint for any organization or team that wants to perform its own benchmarking study to minimize waste, and
2. describes the results of the team that worked on finding the best waste minimization practices for liquid photographic waste.

Benchmarking Definition

Benchmarking is the continuous process of improving products, services, and practices by identifying and understanding the current process, exchanging information with recognized leaders in the field, and implementing meaningful improvements.

Benchmarking is used by a variety of companies and organizations as a quality improvement tool. For this project, the group used the following 12-step benchmarking process:

1. Identify process to be benchmarked
2. Establish management commitment
3. Identify and establish benchmarking team
4. Define and understand the process to be benchmarked
5. Identify metrics
6. Evaluate current performance
7. Identify potential benchmarking partners
8. Collect process data from potential partners
9. Analyze potential partners' data and choose partners
10. Conduct site visits
11. Communicate results
12. Continue to conduct benchmarking of process

Benchmarking Team

The benchmarking team consisted of a project leader, process experts with daily working knowledge of the subject process, and consultants that provided benchmarking expertise.

Continued on the next page...

Benchmarking Team, continued

The team evaluated the current internal processes for liquid photographic waste, created a process flow chart, and defined process metrics. The team then used telephone surveys and written questionnaires to help find industry partners with a similar working environment that had addressed the problems that the team was investigating. The team found two partners: Eastman Kodak Co., and Johnson Space Center/National Aeronautics and Space Administration (NASA).

Site Visit Results

The partners agreed to allow three members of the benchmarking team to visit their sites and learn about their waste minimization practices. The key minimization options fell into the following categories:

1. **Source reduction—** Source reduction is the preferred method of waste minimization, incorporating the following strategies: using correct chemicals; using squeegees to minimize chemical carry-over between baths; determining correct replenishment rates; using floating lids on chemical containers to reduce evaporation, oxidation, and contamination; and using plumbingless minilabs.
2. **Recycle/recovery of components—** Recycling and recovering components such as silver may be accomplished through metallic replacement (chemical replacement cartridge), electrolytic recovery, precipitation, reverse osmosis, ion exchange, and evaporation.
3. **Regeneration/reuse of solutions—** Good waste minimization results also can be achieved through the regeneration and reuse of solutions such as bleaches, fixing baths, wash waters, developers and stabilizers, and stop baths.
4. **Treatment of residuals—** Although treatment of residuals is not considered a true waste minimization technique, Kodak is currently researching a variety of techniques besides high temperature incineration.

Also, both partners offered suggestions for best management practices that covered system design, water control, and process and monitoring considerations.

Additional Benefit

The project had an unexpected side benefit—DOE personnel from across the country were able to network and exchange ideas with their peers at similar sites.

Contents

Figures

Acronyms

BCS	Boeing Computer Systems
BMP	Best Management Practices
CRC	chemical replacement cartridge
COO	Conduct of Operations
D&D	Decommissioning and Decontamination
DOE	U.S. Department of Energy
EDTA	ethylenediaminetetraacetic acid
ES&H	Environmental Safety and Health
FY	Fiscal year
GPP	Guides to Pollution Prevention
HAZWRAP	Hazardous Waste Remedial Actions Program
M&O	Management and Operation
MMES	Martin Marietta Energy Systems
NASA	National Aeronautics and Space Administration
OP	Operating Procedure
PCB	Polychlorinated Biphenyl
PHA	Preliminary Hazard Assessment
PP	Pollution Prevention
REECO	Reynolds Electrical and Engineering Company
RSL	Remote Sensing Laboratory
SLP	Sandia Laboratory Policies
SNL/CA	Sandia National Laboratories, California
SNL/NM	Sandia National Laboratories, New Mexico
SOP	Standard Operating Procedures
VMF	Vehicle Maintenance Fleet
WMCPU	Waste Minimization Crosscut Plan Update
WMin	Waste Minimization
WMIS	Waste Management Information System
WS	Waste Stream
WWTP	Waste Water Treatment Plant

1.0 Introduction

1.1 Background

Executive Order

On August 3, 1993, President Clinton issued Executive Order 12856 "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements", which requires federal agencies to develop voluntary goals to reduce their total releases of toxic pollutants by 50% by December 31, 1999. To meet the demands of the Executive Order and related environmental regulations, the U.S. Department of Energy (DOE) created the 1993 Waste Minimization Crosscut Plan. This plan establishes a DOE-wide goal to reduce all newly generated DOE waste streams as well as pollutants by 50% in annual incremental reductions of 10% per year beginning in fiscal year 1995. (WMCPU, 1993)

DOE Waste Minimization Mission

The Crosscut Plan states that DOE's waste minimization (WMin) mission is

"To reduce DOE multimedia wastes and pollutants by implementing cost-effective waste minimization technologies, practices, and policies, with partners in government and industry while conducting the Department's operations in a regulatory compliant and environmentally sound manner."

DOE Objective

This benchmarking project helps to accomplish one of the major DOE Crosscut Plan Strategic Objectives, which is "to identify and develop technology and exchange information." By learning from "best in class" partners, the DOE can enhance the effectiveness of WMin efforts by exchanging applicable technologies and information with those who are already successful.

Sponsor

The sponsor of this project is the DOE Waste Minimization Division, EM-352. The division's mission is to plan, coordinate, and develop a DOE-wide Waste Minimization and Pollution Prevention Program that results in a decrease in the amount of waste produced by the DOE.

Benchmarking Approach

Benchmarking was chosen as the project approach because it

- has proven capabilities as a quality improvement tool,
- provides flexibility,
- may be applied to many different processes, and
- increases ties with U.S. industry.

For a complete definition of benchmarking and an explanation of the process, refer to Section 2.

1.2 Purpose

Purpose

The purpose of the project was to examine the common waste streams throughout the DOE and determine ways to minimize these waste streams. This report is part of the DOE-wide effort to prevent pollution and minimize common waste streams. The DOE waste minimization effort strives to reduce sources of waste and to recycle wastes and pollutants. Pollution prevention is defined by the DOE as source reduction activities that prevent waste generation and contaminant releases.

This purpose of this report is to

1. provide a blueprint for any organization or team that wants to perform their own benchmarking study to minimize waste, and
2. describe the results of the team that worked on finding the best waste minimization practices for liquid photographic waste.

Project Focus

The project focused on identifying common waste streams throughout the DOE, identifying waste minimization technologies that have been successfully applied to these waste streams, and providing this information to the DOE. Benchmarking provided the methodology for analyzing the internal processes and seeking industry partners that have successfully improved their own waste minimization efforts.

1.3 Report Structure

This document is Volume I in a planned series of waste minimization benchmarking project reports. Volume I includes the background, full project scope, details, and results of the liquid photographic waste case study. A second waste stream, waste motor oil, is included in the project. During the benchmarking process, the waste motor oil team was unable to locate an industry partner that was doing a better job of waste minimization than DOE (at the time of publication). The group decided to perform an internal, DOE-based benchmark. The results of the waste motor oil group will be published in another volume. Volumes will be added as other waste streams are studied.

The following table describes the report structure:

Report Section	Description
1	Identifies purpose, project background, and intent.
2	Describes Sandia's generic 12-step benchmarking methodology, which can be adapted by any organization that wants to apply benchmarking to process improvement.
3	Describes how the project was conducted, using the 12 steps of the benchmarking methodology as a framework. Details from the liquid photographic waste team are included. **Waste minimization practices, techniques, and recommendations are included in Section 3.11.**
4	Describes the lessons learned that might be helpful to other organizations that use this benchmarking methodology.

2.0 Benchmarking Methodology

Introduction

This section describes the generic process of benchmarking, as defined by Sandia's Process Improvement/Benchmarking Team.

Benchmarking Definition

Benchmarking is the continuous process of improving products, services, and practices by

- identifying and understanding customer requirements and process performance,
- exchanging information with recognized leaders (internal and external to the organization),
- implementing meaningful improvements, and
- recalibrating the process by assessing the progress and monitoring the trends and results.

Author Robert Camp has defined benchmarking as "the search for industry 'best practices' that lead to superior performance." (Camp, 1989)

Benchmarking Steps

The following is a flow chart of the 12-step benchmarking methodology (Figure 2-1) used at Sandia.

Figure 2-1. 12-Step Benchmarking Methodology

2.1 Defining the Benchmarking Process

Benchmarking Process

The following table shows the steps that comprise the benchmarking process Steps 1 through 6 reflect internal process improvement. Steps 7 through 12 reflect external activities.

Step	Activity
1	**Identify Process to be Benchmarked** The process selected must be narrow enough in scope that it is manageable. The process must be important to the work or business function and be customer-focused because a substantial amount of resources (i.e., people, time, and funds) will be required to conduct the benchmark. The result must improve the process and add value.
2	**Establish Management Commitment** Management is defined as the person(s) who has the authority to allocate resources (people, time, and funds) and who is ultimately responsible for the outcome of the benchmarking activity. Management • has the responsibility to make the effort to understand the fundamentals of benchmarking and to demonstrate its willingness to implement the results. • needs to support the team and its recommendations with resources, encouragement, and commitment. • has the right to expect frequent updates from the benchmarking team (e.g., verbal reports, meeting minutes, reports, periodic presentations).
3	**Identify and Establish Benchmarking Team** The benchmarking team members include • **process experts** who have extensive knowledge of the process through their daily jobs; these are the people impacted by any changes. • **resource personnel** such as facilitators, trainers, quality or benchmarking consultants, information specialists, technical writers, and statisticians. • a **project leader** who guides the benchmarking process. The team may need training in benchmarking techniques, including process definition, the benchmarking process, quality tools, questionnaire design, and interviewing techniques. The team members must understand their roles and responsibilities and commit to a common team purpose or goal. The members must attend and participate in all meetings and complete assignments. *continued on the next page...*

Step	Activity
4	**Define and Understand the Process to be Benchmarked** The team defines the process through an understanding of important process elements: inputs, outputs, suppliers, and customers. The customer drives the business, and therefore the team needs to understand the customers' wants, needs, and expectations. The team's final output for this step includes a process flow chart depicting the work flow and the relationships between people and organizations. The output from this step will lay the foundation for the remainder of the benchmarking activity.
5	**Identify Metrics** The metrics must be meaningful to the process. Example metrics include customer requirements, cost, cycle time, and quality. Metrics, when possible, should be consistent with established standards (i.e., industrial, national, international). The process metrics will aid in evaluating and assessing the current process. Strength and weakness trends developed from the metrics can identify areas for improvement and provide guidance and direction for selecting improvements to be implemented. Effective metrics will provide guidance for developing survey tools for benchmarking partners.
6	**Evaluate Current Performance** The metrics help to identify the process areas to be improved and the nature of the improvements. The team may need to develop a decision matrix for ranking the improvements. A cost/benefit or return-on-investment analysis may be required to evaluate whether the benchmarking process should be continued. If the recommendation for implementation of the appropriate process improvements is made, it will be necessary to monitor the trends and results.
7	**Identify Potential Benchmarking Partners** Based on the metrics collected from the internal process, the team needs to identify and establish criteria for "best in class" partner selection criteria. The team can identify potential partners through numerous resources: library search and contacts with external organizations, knowledgeable individuals, suppliers, and customers. The team needs to identify a sufficient pool of partners to determine the final few they will visit. *continued on the next page...*
8	**Collect Process Data from Potential Partners** The team develops surveys to obtain preliminary information from potential partners. Surveys may consist of questionnaires, telephone interviews, or face-to-face interviews. (Normally, site interviews are reserved for Step 10.) The survey questions are based on the process metrics and criteria established for selecting partners. Up-front planning on how to analyze the quantitative and qualitative data is essential for developing good surveys.

Step	Activity
9	**Analyze Potential Partners' Data and Choose Partners** The preliminary data is used to select partners for site visits and interviews. The project leader compares the data gathered from the potential partners to the metrics and criteria set by the team. The final partner(s) must have a process that is applicable to various DOE sites. The project leader should make direct comparisons of the data, process parameters, and constraints. The team will analyze the data and determine how to weight and rank criteria in order to select the final partners.
10	**Conduct Site Visits** To gain the maximum benefit from partner site visits, careful and thorough preparation is essential. Preparation includes, but is not limited to, determining appropriate interviewees, assigning team interviewing roles, developing a list of questions and a meeting agenda, and determining how to handle the interview data. The site visit is an opportunity for two-way communication between the benchmarking team and each partner. During the site visit, the team will conduct an in-depth interview. It is essential that the team develop an effective interview guide for each partner before the site visits. After all partners' information is collected, the quantitative and qualitative data are analyzed. A decision matrix may be used to identify and select the partners' practices to be incorporated.
11	**Communicate Results** The team reports results to upper management and all involved parties and develops an action plan that describes the team's recommendations, methods for implementation, and implementation costs and schedule. The findings need to be adaptable to the process and the organization's culture and constraints. The improvements will need to be monitored and evaluated. *continued on the next page...*
12	**Continue to Conduct Benchmarking of Process** The best process today may not be the best process tomorrow. Depending on the level of change in the process, customer requirements, competition, technological advances, and changing business practices, it is important to revisit the process, or specific aspects of the process, periodically.

Reference

Section 2 is an adaptation of Section 2 of the report, *Benchmarking the Property Inventory Process at Sandia National Laboratories*, SAND92-2565. It describes the generic process of benchmarking, as defined by Sandia's Process Improvement/Benchmarking Department.

3.0 Conducting the Project

Adaptation of Benchmarking Methodology

The 12 steps of the benchmarking methodology listed in Section 2 provide the framework for this section.

Benchmarking is a flexible process that lets each team adapt the standard procedure to the unique needs of the project. Because of cost and schedule constraints, the benchmarking process was streamlined and condensed for this project.

The following describes how the project leader and the liquid photographic waste team adapted the benchmarking process to the needs of this project.

3.1 Step 1: Identify Process to be Benchmarked

Identification of Common Waste Streams

Initial activities centered on collecting information on as many DOE waste streams as possible. As a starting point, the Waste Management Information System (WMIS) database provided by the Hazardous Waste Remedial Actions Program (HAZWRAP) was used. Through a subjective analysis of DOE waste streams, 38 common DOE waste streams were identified. (See Appendix A.) Of these 38, two waste streams were chosen for this project. This section describes the selection process.

Decision Process Description

The following table describes the process used to select the two waste streams for this project.

Step	Action
1	**Collect Waste Stream Data** Collect information about waste streams generated in the DOE complex. The following information sources were used: • Waste Management Information System (WMIS) data base, Oak Ridge, TN • Annual waste reduction reports sent to DOE headquarters • DOE process expert's opinions • Queries made to waste minimization site coordinators through this project, including a written survey
2	**Compile Comprehensive List** Compile information collected in Step 1 and categorize by waste type as follows: • Hazardous • Radioactive (low-level and high-level) • Transuranic • Mixed • Sanitary
3	**Evaluate Waste Stream by Function or Volume** For each waste stream on the comprehensive list, ask the following questions: • Is the waste stream infrastructure-related? For example, does it result from facility operations, such as motor pool, photography, printing, or office work? • Does the waste steam apply to most DOE sites? (Based on process knowledge.) • Does the waste stream create a large volume of waste? The waste stream may not be extremely hazardous, but it may be expensive to process because of the large volume of waste generated. (Large volume is a subjective judgment.) *continued on the next page...*

Step	Action
4	**Distill a Short List of Waste Streams** Select only the waste streams that had affirmative answers in Step 3. (See Appendix A.)
5	**Choose Waste Streams for Study** Two waste streams, liquid photographic waste and waste motor oil, were chosen for the following reasons: • Manageable process to define and understand • Good chance of success • Process experts were easily found and readily available in the DOE complex • Vehicle fleet maintenance working group already existed. The Fleet and Plant Operations and Maintenance group was created by the Waste Minimization Contractor Coordination Group.

☞ OUTCOME OF BENCHMARKING STEP 1:

Processes chosen for benchmarking:

- Liquid photographic waste
- Waste motor oil

NOTE: Because the waste motor oil team was unable to find, at the time of publication, an industry partner that practiced better waste minimization techniques than were currently in use by some DOE sites, the team decided to perform an internal benchmark that would provide a profile of the best DOE efforts. Therefore, information on the waste motor oil team will be detailed in another volume.

3.2 Step 2: Establish Management Commitment

Strong DOE Commitment

Because of DOE's emphasis on minimizing waste, management commitment was a positive element in this project. Management at all levels provided support, funding, resources, and suggestions. The DOE sponsor for this project is the Waste Minimization Division, EM-352. The project also had the support of the individual team members' management.

All Levels

Management commitment was provided at many levels for this project, including the following:

- Headquarters provided support through project funding and guidance.
- The Albuquerque Field Office provided support through the WMin coordinator.
- Site management provided support by allowing the process experts the time to participate.
- Sandia management provided support through benchmarking expertise and trainers.

☞ OUTCOME OF BENCHMARKING STEP 2:
DOE management committed resources at local, regional, and national levels.

3.3 Step 3: Identify and Establish Benchmarking Team

Team Members

A benchmarking team usually consists of a project leader, process experts, management, and support personnel. Not all team members are required to participate at all times. Some team members may perform more than one role, as needed, for the team at large and smaller subteams.

Finding Team Members

The project leader used the following sources to find benchmarking team members:

- Networking
- Contacts within the DOE
- Proceedings from waste minimization conferences
- Discussions with site waste minimization coordinators

NOTE: The team should be as small as possible while including all of the required roles. A good rule of thumb is 4-6 process experts.

Roles and Responsibilities

The following table outlines suggested roles and responsibilities.

Role	Responsibilities
Project Leader Plan, organize, assign tasks, and oversee the benchmarking project.	• Identify the waste stream to be benchmarked • Identify process experts and assemble the team • Manage the project • Arrange for benchmarking training • Report project progress to DOE management and team members • Negotiate commitments with benchmark partners • Coordinate tasks • Attend all workshops and site visits • Oversee report preparation

Roles and Responsibilities, Continued

Role	Responsibilities
DOE Management Provide support and resources.	• Set policy • Provide support and personnel, time, and funds
Trainers/Facilitators Teach participants bench-marking techniques and lead workshops and work sessions to accomplish goals.	• Train team members in: - benchmarking philosophy and methods - process definition and flowcharting - developing questionnaires for telephone contacts and written responses - developing interview questions - proper procedures for site visits • Consult on sensitivity issues • Facilitate working sessions to keep the team on track and lead discussions
Information Specialist Aid the search for potential benchmarking partners.	• Search a variety of data bases using key words to find potential industry partners for benchmarking • Create a packet of materials and potential leads to aid the process experts and project leader in their search
Writer/Recorder Document the benchmarking process.	• Record information at the workshops and transcribe minutes • Write questionnaires, using questions developed by the process experts at the workshop • Provide writing support for project leader, as needed

Team Assignments

The team assignments are suggested, not mandatory. The team assignments listed in the table below were used for this project.

Team	Responsibilities	Members
Planning Team	• Sets the goals of the project • Creates task plans • Defines the cost, schedule, and budget	• Project leader • Local DOE field office waste minimization coordinator • DOE Headquarters EM-352 Representative • Additional suggestions: Members of the planning team might include site waste minimization coordinators, process experts, and site management personnel.
Benchmarking Team	• Performs the work to accomplish the project's goals, including: - Defining the process and its metrics - Setting criteria for industry partners - Developing a questionnaire - Identifying industry partners - Conducting telephone surveys - Developing interview questions - Conducting on-site interviews - Writing progress and project reports - Providing a pool of personnel for the subteams	• Project leader • Process experts (4-6 experts) • Benchmark consultants/facilitators for training and consultation • Support personnel (information specialist, technical writer, scribes to record minutes)
Interview Team	• Visits the industry partners, conducts interviews, and records responses NOTE: It is recommended that team members are trained on benchmarking ethics and site visit techniques.	• **The Questioner—**Has strong interviewing skills, elicits as much information as possible with broad category questions, always a process expert. • **The Listener—**Refers to a long list of detailed questions to make sure enough information is collected to satisfy all the questions, usually a process expert. • **The Scribe/Facilitator—**Takes detailed notes and monitors the agenda to keep the site visit on track, usually the project leader.

☞ OUTCOME OF BENCHMARKING STEP 3:
Planning team, benchmarking team, and interview team successfully assembled.

3.4 Step 4: Define and Understand the Process to be Benchmarked

Process Foundation

Step 4 is the most important step in the benchmarking process because it lays the foundation for all future activity. The team must define and understand the existing process before examining another's process. This step establishes the baseline from which to measure performance gaps.

Team Convenes

The entire team gathered for the first time in Step 4. The project leader, benchmarking consultants, process experts, information specialist, and support staff attended a workshop, the first in a series of three.

Workshop Goals

The goals of the first workshop were to

- Define and understand the process to be benchmarked.
- Create a flow chart of the generic process.
- Define the metrics of the process (Step 5).
- Define the criteria for choosing potential partners (Step 7).

The workshop also had important auxiliary goals, which were to:

- Coalesce the team into a cooperative, working unit.
- Train the team in benchmarking methodology.

Workshop Activities

The two-day workshop was held to provide training and a work session for the entire benchmarking team.

The stage table below summarizes the workshop activities related to Step 4 A detailed description of the activities follows the stage table.

Stage	Activity
1	Workshop facilitators directed team-building exercises to help the team integrate into a cooperative, working unit.
2	Workshop facilitators trained the team in the benchmarking methodology so team members understand the group process, the task, the commitment, and the work involved to complete the project.

Stage 1 — Team Building

Team Building

One of the first activities was a team-building exercise. The team was charged with defining:

1. Team name
2. Motto
3. Mission statement

The group exchanged ideas, brainstormed, and got to know one another through the group exercise.

The outcome of the tasks:

Team Name	The Foto Fixers
Motto	Less is Better

Mission Statement Purpose

The mission statement helped the team establish common goal, narrow the focus, and define the group's mission. The mission statement provided a touchstone to prevent the group from straying off the track.

The mission statement also helped to keep the target small. If, for example, the liquid photographic waste group had decided to minimize ALL photographic process waste, such as ruined paper, used film, and so on, the target would have been too large, the waste minimization process would have become unmanageable, and the group would have lost focus.

Stage 2 — Train the Process Experts

The process experts were chosen for their knowledge of their fields and the tasks they perform in their daily jobs. However, they needed training in how the process of benchmarking works. The first workshop also provided training in the 12-step benchmarking process (refer to Section 2). The trainers and facilitators from the Process Improvement/Benchmarking Department at Sandia guided the workshop and provided training.

Also, the training facilitators made sure everyone was familiar with flow charting techniques and terminology before proceeding with the flow charting activities.

Stage 3 — Create a Flow Chart That Works for All Members

Process Flow Chart

The process experts came from a variety of sites that had different procedures to accomplish the same task. Each site was unique, but the final product was the same. Regardless of the site, the team members produced photographic products for their customers.

Process Parameters

All processes have the following common parameters:

- Inputs
- Suppliers
- Outputs
- Customers

The team used the parameters above to help them define a particular process that produces a liquid photographic waste stream. For each parameter, the team brainstormed for ideas. After making four lists, the group reviewed each listed component to see if it was directly related to the liquid photographic waste stream, or if it was tangential. The mission statement provided a reminder for keeping the group focused. The team members deleted some items and combined and revised others. The final lists are shown below.

Inputs

The inputs for the liquid photographic waste stream are

- Up front chemicals
- Processing equipment
- Film/paper
- Filters
- Exhausted chemicals
- Process mistakes
- Waste water treatment system
- Staff knowledge/work/process implementation
- Facility design
- By-products of photography processes
- By-products of treatment processes
- Regulations/requirements
- Procedures/processes
- Work requests
- Conduct of Operations (code of procedures) and Formality of Operations

Suppliers

The suppliers for the liquid photographic waste stream are

- Chemical suppliers
- Water works/utility company
- Photo paper and film
- Equipment manufacturers
- Customer's work requests
- Technical/instruction publications

Continued on the next page...

Suppliers, continued

- Power company
- DOE
- Regulators
- Management/staff
- Maintenance service
- Facility service
- Waste organization

Customers

The customers of the liquid photographic waste stream are

- Internal management
- DOE
- Regulatory agencies
- The public
- Storage treatment and disposal facility
- Shippers
- Public treatment works

Outputs

The outputs of the liquid photographic waste stream are

- Effluent/waste water (treated vs. nontreated, hazardous vs. nonhazardous)
- Liquid waste (treated vs. nontreated, hazardous vs. nonhazardous)
- Being in compliance/passing audits (regulated/nonregulated)
- Self-assessments
- Testing process
- Reports
- Operational data base

Flow Chart

After the lists were finalized, the team created a flow chart (Figure 3-1) for the liquid photographic waste process.

☞ OUTCOME OF BENCHMARKING STEP 4:
Photographic process inputs, outputs, customers, and suppliers were identified. A flow chart of the process was completed.

Figure 3-1. Photographic Waste Administrative Process

Figure 3-1. Photographic Waste Administrative Process, continued

3.5 Step 5: Identify Metrics

Definition

Metrics are the measures of the internal process. Metrics allow evaluation and assessment of existing performance and provide points of contrast after the lessons learned from the benchmarking activity have been applied.

Purpose

Metrics help the team create questions for finding the right industry partner and form the foundation for questionnaire development and interview questions.

Metrics

After the process flow chart was created (see Step 4), the facilitator led the team through a discussion of the metrics that applied to its process and defined a list of metrics.

The group decided that the following metrics were relevant for finding potential industry partners:

- Total gallons of effluent discharged per year
- Gallons of photo chemicals used per year
- Ratio of materials used per product produced
- pH range of effluent (element tracking)
- Information on out-of-tolerance occurrences
- Concentrations of key components (analytical analysis)
- Preliminary Hazard Assessment (PHA) or risk assessment of work conditions
- Machine utilization/effluent not treated (balance workflow to machine utilization
- Frequency of sampling
- Number of process technicians

NOTE: Not all of the metrics are easily obtainable measures within DOE.

☞ OUTCOME OF BENCHMARKING STEP 5:
Metrics were defined that provide the measures of the internal process and identify the criteria for finding potential industry partners.

3.6 Step 6: Evaluate Current Performance

Modification of Step 6

This step was not explored in depth because of the diversity of the sites. However, each process expert was urged to use information from the workshop to apply to his or her own process.

Information Exchange

The team performed an informal evaluation of a site's performance by exchanging information and comparing activities and processes. Each process expert had the opportunity to discuss and explain his or her site process during the first workshop.

Value of Networking

Most of the participants said that this workshop was the first time they were able to meet with their peers. They learned new ideas from other sites' processes and felt the workshop had provided a networking opportunity. The process experts said that the variances in environmental laws and regulations that apply to the different sites was of great interest.

A photography technologist reported that the workshop had helped him because of the supportive network that the benchmarking process fosters. Improved work relationships resulted. He reported that when problems arise, they are not seen as crises, but manageable problems with attainable solutions.

> ☞ OUTCOME OF BENCHMARKING STEP 6:
> Individual team members shared information on his or her process with the other process experts and established network contacts for future problem solving.

3.7 Step 7: Identify Potential Benchmarking Partners

Search Parameters

The search parameters for identifying potential partners were based on the metrics and criteria established by the process experts at the process flow workshop.

Defining the criteria limited the search to partners that will fit the team's needs The liquid photographic waste team needed to find a partner that had a variety of operations, such as black and white, color, and motion picture processing. A company that only did black and white processing would not fit the criteria because their operations would not be diverse enough to apply to a majority of DOE sites.

Criteria

The liquid photographic waste team defined the following criteria as being important for choosing an appropriate partner:

- Size of staff
- Size of physical plant
- Number of machines
- Kind of business
  - Custom
  - Amateur
  - Aerial
  - X-ray
  - Motion picture
  - Other
- Regulations
  - Federal
  - State
  - County
  - City
  - Other

Identification of Potential Partners

There are a variety of sources for identifying potential partners, including the following:

- Literature search by an information specialist
- Process experts' suggestions
- Contacts through customers or suppliers
- Trade associations or publications

Literature Search

The technical library information specialist was able to start the search before the first workshop, based on the chosen waste stream and the project goals. The information specialist attended the first workshop to familiarize herself with the partner requirements. After the workshop, the metric and criteria lists were given to the information specialist to use as the basis for a literature search to find potential partners.

The literature search steps to identify potential industry partners are summarized below.

Step	Action
1	Search the appropriate data bases - using key words suggested by the criteria provided by the benchmarking team. - for companies that are patenting innovative techniques.
2	Review technical journals in the subject field.
3	Check reference sources for company information.
4	Verify company addresses and telephone numbers.
5	Identify possible contacts to whom benchmarking questionnaires can be sent.
6	Prepare a report, listing all companies and contacts.

The list of companies and contacts was provided to the group at the second workshop (see section 3.8).

Process Experts' Suggestions

In this case, the best source for partners was the knowledge available from the process experts. Their networking contacts were valuable in supplying information that was not available through published sources. Creative brainstorming at the second workshop yielded good suggestions for potential partners, including the two final partners, NASA and Kodak.

Results

The literature search and process expert networking initially identified 42 companies for the liquid photographic waste team.

☞ OUTCOME OF BENCHMARKING STEP 7:
A list of potential partners was finalized.

3.8 Step 8: Collect Process Data from Potential Partners

Data Collection Methods

The main tools for gathering initial process data from potential partners is a questionnaire, either verbal or written. Both types were used for this project.

Questionnaire Development Training

The benchmarking team reconvened for the second workshop to learn questionnaire development techniques and to define the questions it wanted to pose to potential partners.

Refer to Appendix B for an abbreviated training guide on questionnaire development techniques. Refer to Appendix C for the final telephone and written questionnaires used in this project.

Telephone Questionnaire Purpose

The telephone questionnaire was not meant to be an exhaustive survey, but a brief inquiry to determine whether the company would be interested in participating and whether the company was suitable for benchmarking. The telephone questionnaire provided a filter, focusing on major processes rather than details of the company's operations.

Written Questionnaire Purpose

The purpose of the written questionnaire was to collect the needed information to choose the best partner.

The written questionnaire incorporated most of the metrics defined in the first major workshop on process definition. The written questionnaire was sent only to the companies contacted by telephone that met the criteria, that expressed an interest in participating, and that would possibly provide innovative techniques in waste minimization.

Questionnaire Process

The following table describes the process for developing and using both the telephone and written questionnaires:

Step	Team Member	Action
1	Process Experts	• Use the metrics to develo • Using process knowledge, make sure the questions will help identify good partners and are not just "nice to know" information
2	Project Leader and Technical Writer	• Use the rough questions developed at the workshop to create the telephone questionnaire and the written questionnaire
3	Project Leader	• Divide the names and tel potential partners among the process experts (2 or 3 per process expert) • Fax the final version of the telephone questionnaire to the process experts • Send a rough draft of the written questionnaire to the process experts for comment
4	Process Expert	• Call the companies and c questionnaire • Report the results to the project leader • Review the written questionnaire and send the suggestions to the project leader

Results

Of the 24 initial contacts made by the liquid photographic waste team, 11 companies

- had processes that were appropriate for comparison to the DOE's process defined by the process experts and
- were willing to participate.

Written questionnaires were sent to these companies. Of the 11 written questionnaires sent, 7 were returned. (This return rate of 64% exceeds the average return rate of 30-60% for prescreened written questionnaires.)

☞ OUTCOME OF BENCHMARKING STEP 8:

1) Telephone questionnaire "qualified" 11 potential partners
2) Written questionnaire follow-up provided 7 responses used for further analysis.

3.9 Step 9: Analyze Potential Partners' Data and Choose Partners

The answers to the written questionnaires provided the data for analysis and for selection of a benchmarking partner. (The written questionnaire is shown in Appendix C.) The table below shows the criteria used to select partners.

Criteria	Explanation
Size of Staff	The team was looking for a laboratory that had a medium-to-large size staff (six or more laboratory workers, excluding photographers). The size of the staff indicated that enough photography products were processed to make WMin efforts worthwhile and cost-effective.
Diversity of Operations	Laboratories with diverse operations would mirror DOE facilities. For example, a one-hour photo shop that does only color print processing did not have the desired diversity.
Waste Minimization Efforts	The team looked for companies with strong management and worker support for waste minimization through good training, thorough written procedures, and a commitment to waste minimization.
Best Management Practices	Companies were evaluated on how many of the Best Management Practices listed on the questionnaire were already in use at their site.

Out of the seven potential partners that returned the questionnaire, three companies met the requirements stated above. The project leader called the three finalists and discussed their waste minimization efforts and successes. The two that had the most active waste minimization programs were chosen.

☞ OUTCOME OF BENCHMARKING STEP 9:
Partners selected for on-site benchmarking:

- Eastman Kodak Co.
- Johnson Space Center/NASA

3.10 Step 10: Conduct Site Visits

Overview

The industry site visit is the final tool to help the team gather information on how to improve each DOE site's waste minimization process.

Site Visit Training

The interview team, a subset of the benchmarking team, convened for a third workshop to learn interview techniques, rules of conduct, and agenda development skills.

Refer to Appendix D for an abbreviated training guide on on-site interviewing techniques. Refer to Appendix E for the final interview question set used in this project.

Site Visit Process

The following table shows the site visit process.

Step	Action	Team Member
1	• Contact the chosen partners and make arrangements for the site visit through a telephone call and a formal letter. • Contact the companies not selected and thank them for their time and tell them the publication date of the final report.	Project Leader
2	• Train the team in interviewing skills, site visit standards, etiquette, benchmarking ethics, and handling sensitive information.	Benchmarking Facilitators
3	• Create the agenda for the site visit.	Interview Team, Project Leader
4	• Develop interview questions. (A helpful source was the Guides to Pollution Prevention, The Photoprocessing Industry, published by the EPA.)	Interview Team (Process Experts, Project Leader)
5	• Send the agenda, interview questions, any information requested by the partners, and auxiliary documentation (such as benchmarking information) to the partners.	Project Leader
6	• Visit the site, using the interview questions to keep the visit focused.	Interview Team
7	• Analyze the information and report on what is useful to the team.	Interview Team

3.10.1 Eastman Kodak Site Visit

The first site visit was performed at the Eastman Kodak Company headquarters in Rochester, New York.

Rather than follow the prepared agenda and question list, Kodak conducted a series of presentations by staff members, including a comprehensive tour of Kodak's research and development laboratories. Kodak has extensive experience in hosting visitors interested in waste minimization, so the group followed the program offered by Kodak. The team recorded answers to their specific questions as they were covered during Kodak's presentation.

The process experts received a wealth of information, verbally and in written documents. Some time was spent discussing up-coming waste minimization technologies, some of which were presented in the first quarter of 1994 at the National Association of Photographic Manufacturers Association convention.

Summary of Kodak Visit

The visit to Kodak covered the following topics:

- Overview of Kodak health, safety, and environment programs
- Introduction to Customer Imaging Environment Support Services
- Overview of Environmental Sciences Section
- Tour of the following processing areas:
  - Motion picture
  - E-6, a color reversal process
  - Aerial
  - C-41, a color negative process
  - RA-4, a printing process
- Strategies for environmental compliance
- Tour of Environmental Sciences Section Laboratories
- Wrap up, questions, comments

3.10.2 Johnson Space Center/NASA Site Visit

The second site visit was performed at the Johnson Space Center/NASA site in Houston, Texas.

This visit paralleled the team's expectations for a site visit because the scripted interview was followed. However, not all NASA personnel were available, due to other commitments. The main contact person was able to answer all of the team's questions because he had been instrumental in many of the changes made in NASA's waste minimization efforts over the past few years.

Summary of NASA Visit

The visit to NASA followed this agenda:

- Interview NASA contact
- Tour photography operations
- Discuss quality control issues with a photographic chemist to finish answering interview questions
- Wrap up, questions, comments

☞ OUTCOME OF BENCHMARKING STEP 10:
The interview team completed site visits at
- Eastman Kodak Co.
- Johnson Space Center/NASA

3.11 Step 11: Communicate Results

Overview

This section briefly summarizes the site visits and what was learned from the partners. The section discusses waste streams generated by photoprocessors and the four key minimization options. Finally, this section provides a list of Best Management Practices (BMP) learned from the two industrial partners.

One major recommendation from the DOE process experts to photo labs is to stay in touch with their chemical manufacturers, touching base every few months to tap the wealth of process and chemical information that manufacturers have and are willing to share.

Much of the information in this section is not new, but served as reminders of what the process experts already knew. Part of the benchmarking methodology is to constantly re-evaluate the target process to see if any changes can be incorporated that will improve the process.

Normally, Step 11 of the benchmarking methodology includes implementing improvements and monitoring the results. Because this project deals with a consensus (i.e., generic) process, and a variety of sites, actual implementation was not possible. The purpose of this section is to provide results and offer options so individual sites may create their own implementation plans. The tables are comprised of information supplied by Kodak and EPA's <u>Guides to Pollution Prevention, the Photoprocessing Industry</u>.

NOTE: Refer to Appendix F for a list of resources and contacts for expert help in waste minimization in photography.

Key minimization options discussed were

1. Source Reduction
2. Recycle/Recovery of Components
3. Regeneration/Reuse of Solutions
4. Treatment of Residuals

Kodak Site Visit

Kodak stressed their commitment to helping customers solve technical, management, and transportation problems with photographic waste effluents. They demonstrated advancements that customers could use to measure and treat waste streams. Upcoming waste minimization technologies were presented.

Johnson Space Center/NASA Site Visit

Johnson Space Center/NASA is developing a comprehensive program to ensure all environmental discharges are in compliance. A systematic waste reduction program will be in place to ensure that these reductions are being implemented in the most cost-effective manner.

Waste Streams

Wastes generated by photoprocessors are primarily aqueous effluents. These may be categorized as: process bath wastes, color developer wastes, and bleach/fix/bleach-fix wastes (Freeman, 1990).

The following table lists the common solutions that comprise the effluents, their constituents, and the environmental concerns they cause. (GPP, 1991)

Solution	Constituents	Environmental Concern
Prehardeners, hardeners, and prebaths	Organic chemicals Chromium compounds	Oxygen demand Toxic metals
Developers	Organic chemicals	Oxygen demand
Stop baths	Organic chemicals	Oxygen demand
Ferricyanide bleaches	Ferricyanide	Toxic chemical
Dichromate bleaches	Organic chemicals Chromium compounds	Oxygen demand Toxic metals
Clearing baths	Organic chemicals	Oxygen demand
Fixing Baths	Organic chemicals Silver Thiocyanate Ammonium Compounds Sulfur compounds	Oxygen demand Toxic metals Toxic chemicals Ammonia Possible hydrogen sulfide (H_2S) generation
Neutralizers	Organic chemicals	Oxygen demand
Stabilizers	Phosphate	Bio-nutrients
Sound-track fixer or redeveloper	Organic chemical Ammonium compounds	Oxygen demand Ammonia
Monobaths	Organic chemicals	Oxygen demand
In addition, photoprocessing solutions may be acidic or alkaline.		

3.11.1. Source Reduction

Source reduction is the preferred method of waste minimization but must be used in combination with other methods to ensure the most effective strategy.

The following table lists source reduction methods.

Method	Description	Comments

Using Correct Chemicals	Choose chemicals that
	
	• produce the lowest waste
	  - can be treated by a waste treatment facility
	  - have low replenishment rates
	• use the same manufacturer's chemicals within a single process. Mixing different brands within a single process may produce nontreatable matrices or void existing treatment technologies.
		The chemicals that are best for a lab will depend on factors such as
		
		• Effluent regulations in the area and chemical limits that affect the laboratory.
		• Utilization of the film and paper processor.
		• Level of equipment, chemical, and maintenance costs that the laboratory can justify.
		• Commitment to reduce effluent discharges.
		• Space limitations.
		• Other needs unique to each laboratory.

Squeegees	Squeegees provide a simple and effective way to reduce carryover of processing solutions and wash waters. Properly installed, they can reduce solution or wash-water carryout by 75 percent or more. The following steps will result in dramatically improved squeegee function: • change often • use correct squeegee material for right solution • wash squeegee every 15 minutes • wipe squeegee frequently during process	• Install squeegees following all washes and processing solutions in continuous processing machines. (Squeegees are not recommended in some locations because the carryover adds needed dilution to the next solution.) It is also not practical or possible to use them on processors such as rack-and-tank, basket, or drum processors. • Check the specifications for the process for recommended placement of squeegees. *continued on the next page...*

Method	Description	Comments
Replenishment Rates	Replenishment rates are determined by factors such as • the type and amount of the photographic material being processed, • the exposure level of the material, • processor speed, • solution carry-in and carry-out, • concentrations of the reaction and decomposition products, and • process control. Usually the recommended replenishment rates exceed the amount needed to maintain the solution level, resulting in an overflow that is either discharged to the drain or collected for treatment and possible reuse.	Check for the following: • The correct replenishment rates are being used. • The correct process specifications are being used. • The replenisher-delivery systems are operating properly.
Floating Lids	Using floating lids on solution-storage containers can • double the useful storage life of solutions by reducing oxidation and evaporation. • reduce contamination from dust and dirt.	• Mix only the amount of solution that can be used during its useful storage life to minimize solution loss from oxidation and evaporation.
Plumbingless Minilabs	Plumbingless minilabs use a proprietary chemical stabilizer in place of wash water. While conventional minilabs discharge 20 to 25 gallons of effluent per roll of film processed, plumbingless minilabs discharge less than 0.1 gallon of effluent per roll.	Although the volume of effluent is greatly reduced, the concentrations of contaminants are much higher than for the conventional minilabs. Wherever there are concentration limits on sewer discharges, potential users should review this point with local authorities if silver can be recovered from this effluent using either the metallic replacement or electrolytic processes described in the next table.

3.11.2 Recycle/Recover Components

As much as 80 percent of the total silver processed for black-and-white positives and almost 100 percent of the silver processed in color work will end up in the fixer or bleach-fix solution. Silver is also present in the rinse water following the fixer or bleach-fix due to carry-over. The amount of silver in rinse water is a small fraction of that in the fixer or bleach-fix solutions, but can be economically recovered when high volumes of rinse water are used. A variety of equipment types and sizes are available for silver recovery.

The table below discusses silver recovery methods.

Comparison of Silver Recovery Methods			Applicable Production Volume		
Method	**Advantages**	**Disadvantages**	**Low**	**Medium**	**High**
Metallic Replacement (Chemical Replacement Cartridge (CRC))	• Low investment • Low operating cost • Simplest operation	• pH sensitive • High iron content of effluent • Silver recovered as sludge • High silver concentration in effluent unless two units are in series • Overall high cost due to frequent changing of cartridges	X	X	
Electrolytic Recovery	• Recovers silver as pure metal • High silver recovery rate • Most economical	• Potential for sulfide formation • High silver concentration in effluent • pH sensitive	X	X	X
Precipitation	• Can attain 0.1 milligrams of silver per liter (mg Ag/L) • Moderate investment • Relatively simple technology	• Complex operation • Silver recovered as sludge • Treated solution cannot be reused • Potential H_2S release for sodium sulfide system • Must know silver concentration for proper dosage • Can be very time-consuming • Phase separation stage is critical	X	X	

Continued on the next page....

Comparison of Silver Recovery Methods			Applicable Production Volume		
Method	**Advantages**	**Disadvantages**	**Low**	**Medium**	**High**
Reverse Osmosis	• Also recovers other chemicals • Purified water is recyclable	• Concentrate requires further processing • High investment • High operating cost • Distillates may need further treatment • Need to control biogrowth	X		
Ion Exchange	• Can attain 0.1-2.0 mg Ag/L • Good for very low Ag limits	• Only for dilute effluent • Complex operation • High investment • Distillates may need further treatment • Need to control biogrowth • High replacement cost for resins		X	X
Evaporation	• Minimum aqueous effluent • Water conservation	• High energy requirement • Silver recovered as a sludge • Organic contaminant buildup • Potential air emissions • High initial cost • Distillates may need further treatment • Need to control biogrowth	X		

3.11.3 Regenerate/Reuse Components

The following table listsavailable treatments for the regeneration and reuse of chemistry and wash waters, ranked in order of the ease and effectiveness for waste volume reduction.

		Production Volume Required For Method to be Effective			**Comments**
Treatment	**Description**	**Low**	**Mediu m**	**High**	
1. Bleaches	Many bleaches are recovered and reused. Recovery of EDTA (ethylenediaminetetraacetic acid) type bleaches is very common and regeneration and reuse is done easily. Ferricyanide bleaches have been recovered and reused for years. Some bleaches are designed for low replenishment rates.	X	X	X	Requires more labor, less waste recovery potential than fixing bath treatment
2. Fixing Baths	With in-line desilvering, it is possible to reduce replenishment rates by 50-75%. Recent work has proven batch desilvering of overflow with reuse is feasible.	X	X	X	Simple to install, economical; impacts silver concentration and subsequent wash water
3. Wash Waters	Spent rinse water can be treated to restore purity and recycled for rinsing. A small portion of incoming clean water is added to the recycled water stream and an equivalent overflow goes to the sewer drain after the fixer wash. A single recycling system can serve several photoprocessor units.	X	X	X	Simple to install, low to moderate cost
4. Developers	Most commonly used technique is ion exchange. Electrodialysis is used in Japan and not commonly in the United States. Some developers are formulated to be reused directly. Some formulations are designed for a very low replenishment rate.			X	Complex, high technical skills required, expensive
5. Stabilizers	Recent experimentation has shown it may be possible to reduce replenishment rates if stabilizers are recirculated through resins or activated carbon			X	Easy, low cost, low maintenance
6. Stop Baths	For the most part, stop baths are not reused. In some cases, formulas have been modified for very low replenishment rates. pH control can minimize usage.			X	

3.11.4 Treatment of Residuals

Treatment is not a true waste minimization technique. It must be done when the production of waste is unavoidable. The goal of treatment is to convert the effluent to a form that can be discharged legally to a sewer system.

For facilities that cannot discharge to a Waste Water Treatment Plant (WWTP), volume reduction for vacuum evaporation or distillation can minimize amounts to be hauled offsite. Also, high temperature incineration is the only final treatment currently recommended by Kodak. Most users would have to contract services for any of the treatments listed below. All would be costly. Good practices would reinforce the practicality of minimizing waste at the beginning of each process.

The following treatment technologies are some of the technologies under investigation by Kodak:

Treatment	Description	Comments
1. Chemical Oxidation	• Various oxidants including hydrogen peroxide, hypochlorite, ozone, and combinations of oxidants with and without catalysts	• Limited success on photo solutions
2. Electrolytic Oxidation	• Various electrode combinations commercially available	• Not ready for application to photoprocessing
3. High Pressure, High Temperature Techniques	• Wet air oxidation • Supercritical water oxidation	• Experimental • Not an on-site treatment process
4. Biological	• Recommended treatment when photo solutions are 10% or less of total input to WWTP; partial treatment is advised when photo solutions are 100% of input to WWTP	• Promising
5. Powdered Activated Carbon Treatment	• Specialized biological treatment system	• Experimental
6. High Temperature Incineration	• Recommended treatment for photo solutions and evaporator residues; must be over 1500 °F	• Only final treatment recommended by Kodak

3.11.5 Best Management Practices

The following lists best management practices (BMPs) that were learned from the site visits that are most applicable to DOE site processes. The lists are compilations from both sites.

System Design

- Conduct a thorough systems analysis. Look at how business is being done today, not how it was done when the facility was designed or built.
- Know your regulatory discharge or sewer codes.
- Cut down the number of systems in use; trim the laboratory profile.
- Have up-to-date and clearly written procedures available.
- Size equipment and capacities to actual needs.
- Purchase low-maintenance equipment, even if the initial cost is higher.
- Work closely with vendors to ensure proper use/application of products.
- Stay in touch with manufacturers and attend trade shows.
- Make sure your test labs are accredited by your state.
- Keep abreast of new technology.

Water Control

- Perform a systems assessment before changing the water volume to ensure the product quality stays high.
- Perform regular water use audits.
- Use water savers. Wash water savers can reduce water usage by 25-65%.
- Control inventories of processing chemicals so they are used before their expiration dates.
- Conserve wash water and energy by equipping machine with solenoids to turn off water.

Processing Considerations

- Process in batches for better labor allocation and less processor waste.
- Make up processing solutions only in quantities needed to meet realistic processing volumes.
- Improve quality control for all processes to prevent unnecessary discharges.
- Use floating lids or balls on all solution tanks to prevent loss through oxidation or evaporation.
- Properly separate film types early in the process to avoid processing mistakes.
- Install sticky pads at the entrance to lab facilities to reduce the dust in solutions and on film and prints. The pads should be changed often.
- Use air or vacuum squeegees if feasible.
- Do not mix different brands of chemicals.

Monitoring Considerations

- Calibrate flow meters (at least annually).
- Monitor replenishment rates.
- Monitor silver in effluent throughout the waste stream.

☞ OUTCOME OF BENCHMARKING STEP 11:

Source reduction, recycle/recovery, regeneration/reuse, treatment techniques, and best management practiceswere documented for possible improvement to minimize waste at DOE photography labs.

3.12 Step 12: Continue to Conduct Benchmarking of Process

Normally, benchmarking is an ongoing process. The best waste minimization technology today may be outmoded and outclassed by new developments. This step is not currently being pursued because of cost and schedule constraints, but would be necessary for actual process improvements.

4.0 Conclusions and Recommendations

Results and Recommendations

Because results and recommendations are an integral part of the benchmarking effort, they are included in the main body of the report. See Section 3.11 for the results of the benchmarking project for liquid photographic waste and recommendations for best management practices.

Learning Process

The benchmarking process is also a learning process. As the project progresses, the most important quality for a team to have is the ability to be flexible, to shift gears, and to handle the unexpected, particularly during site visits. This section is written for benchmarking project leaders or team members to help them anticipate and hopefully avoid pitfalls.

4.1 Lessons Learned by the Project Leader

Planning

The following provides suggestions for planning activities:

- Keep complete and organized files of all correspondence and documentation.
- Keep the correspondence with partners and potential partners in a separate file for easy access.
- Plan the workshops carefully. Verify the logistics prior to the start of the meeting to avoid delays or inconveniences during the meeting.
- Have a laptop computer at the workshops to record the activities directly.
- Be flexible. The project leader needs to be willing to adapt if the team comes to a dead end in any part of the benchmark process.
- Communicate regularly with sponsors.

Modifying the Methodology

A full benchmark is a long and rigorous process; the team had to modify the benchmark process to accommodate the needs of the customer, DOE management. Several steps of the benchmark process can be successfully modified but none can be eliminated. Implementation, which is a major part of traditional benchmarking, could not be done with this project because the team used a consensus process rather than a specific process. The process information was gathered from a variety of sites so there was no way to write an implementation plan that would apply to more than one site.

Interactions with Team Members

The following provides suggestions for managing team dynamics:

- Have a written "contract" with the benchmark consultant clearly stating requirements, expectations, schedule, and costs. This "contract" or agreement may be dynamic in the beginning.
- Spend the necessary time finding the "right" team members rather than finding the "easy-to-get" team members. Working with highly qualified process experts with extensive experience in waste minimization added to the project's success.

Continued on the next page...

Interactions with Team Members, Continued

- Give process experts plenty of time to discuss their processes with their peers at the workshops.
- Make sure the workshop scribes understand clearly the purpose of the workshop.
- Involve the technical writer from the beginning of the project.
- Have strong facilitators at the workshops to keep the teams focused.
- Be willing to be the "bad guy" if necessary and tell the team members clearly and early if they are not meeting expectations.

Training

Training is an essential step.

Offer "just in time" training staggered throughout the project so the skills are fresh in the minds of the participants.

Analysis

- Have process experts write the draft of the results section for the final report. So much information is collected that only the process experts can decide what is most important and what is the most useful level of detail.

Site Visits

- Try to space interviews at least a week apart to allow time to digest and analyze the data from each visit.
- Make the note-taking guides identical for all team members and number the questions clearly.
- Bring a laptop computer on the site visits so the project leader can begin the report during the debriefing session with other team members.

4.2 Lessons Learned from the Process Experts

Greatest Benefit

The process experts felt that the greatest benefit of the benchmarking process was the opportunity to network with their peers and share process and operations information.

Greatest Value

Process experts reported the following as the greatest value of the workshop to the DOE complex:

"I feel our time will be multiplied many times over by the sharing of experiences and successes with each other. This can generate a very valuable product/tool."

"Peers can discuss the various aspects of their operations and make common sense input to DOE through this workshop. Properly done, this should foster less, but improved oversight."

"I have worked for the DOE complex in photography for 21 years. This is the first experience for me to have any formal contact with any other DOE photo labs. I now have contacts and personal relationships with three other DOE labs which I can use to improve our daily conduct of operations and to help me cope with whatever new environmental regulations may be coming my way."

Biggest Problems

The biggest problems encountered by the process experts included:

- Logistics: getting to scheduled meetings
- Conflicting priorities with other work

4.3 Lessons Learned from the Benchmarking Consultant

- The process sponsor/owner needs to be clearly defined.
- The project leader and benchmarking consultant need mutually agreed upon goals and objectives.
- An agenda and ground rules need to be set and adhered to at workshops.
- The facilitator needs to be trained in process definition and benchmarking methodology.

References

Camp, Robert C. Benchmarking: The Search for Industry Best Practices That Lead to Superior Performance. ASQC Press, 1989.

Freeman, H.M. Hazardous Waste Minimization. McGraw-Hill Publishing Co., 1990.

Guides to Pollution Prevention, The Photoprocessing Industry, (GPP) October 1991, Environmental Protection Agency, Cincinnati, OH.

Ramirez, Shirley, and Hill, S. Gayle. Benchmarking the Property Inventory Process at Sandia National Laboratories, SAND92-2565, UC-9000, Printed July 1993.

Waste Minimization Crosscut Plan Update (WMCPU), Predecisional Draft, September 1993, U.S Department of Energy, Office of the Secretary.

Distribution

1 Jessica Arellano
DOE ALO
Pennsylvania & H Street
Kirtland AFB - ER
Albuquerque NM 87116

3 Belgin Barkenbus
MMES
P.O. Box 2003
Building K-1400. MS-7363
Oak Ridge TN 37831-7363

2 B. Bennington
Waste Isolation Pilot Plant site
Jal Highway
Carlsbad NM 88220

3 Jim Berger
Pacific Northwest Lab
P.O. Box 999, P7-08
Richland WA 99352

1 P. Berglund
DOE - Los Alamos Area Office
528 35th St.
Los Alamos NM 87544

2 Laura Bingham
U.S. DOE
Idaho Operations Office
785 DOE Place
Idaho Falls ID 83402

2 Pat Cannon
EG&G - INEL
P.O. Box 1625
Idaho Falls ID 83415

2 Karen Catlett
U.S. DOE
Operations Office, Oak Ridge
200 Administration Road
Federal Building
Oak Ridge TN 37830

1 David Caughey
DOE - Kansas City Area Office
ES&H Branch - ER -WM
2000 East 95th St.
Kansas City MO 64141-0202

2 Angela Colarusso
U.S. DOE
Nevada Operations Office
2765 S. Highland Avenue
Las Vegas NV 89193-8518

10 Oren Critchfield
U.S. DOE
Albuquerque Operations Office
P.O. Box 5400
Albuquerque NM 87115

2 Ellen Dagan
U.S. DOE
Operations Office, Richland
825 Jadwin, MSIN-A5-19
Richland WA 99352

2 Will Desmare
Mason & Hanger/Pantex Plant
P.O. Box 30020
Amarillo TX 79177

1 Miles Dionisio
EM-552
Trevion II, 404
US DOE
Washington DC 20505-0002

2 Cindy Dutro
REECO
3271 S. Highland Ave. #702
P.O. Box 98521
Las Vegas NV 89193-8521

1 Arnie Edelman
ER-8.2
Germantown, E-227
US DOE
Washington DC 20505-0002

3 Harry Ettinger
Los Alamos National Lab
P.O. Box 1663, MS-K572
Los Alamos NM 87545

3 Dale Fennell
MMES - Waste Mgmt. Div-PORTS
P.O. Box 628, MS-7570
Piketon OH 45661

1 Robert Fleming
EM-431
Trevion II, 206
US DOE
Washington DC 20505-0002

3 Terry Fletcher
WMin - MMES E5
Bldg. C-270
P.O. Box 1410
Paducah KY 42001

3 George Goode
Brookhaven Nat. Lab
Bldg. 535-A
Upton NY 11973-5000

1 Anita Gorski
Envir Serv Grand Junction Project Office
Chem-Nuclear Geotech, Inc.
2597 B 3/4 Road
Grand Junction CO 81502

3 Roy Grant
Argonne National Lab
P.O. Box 2528
Idaho Falls ID 83403-2528

1 Mary Hall
Inhalation Toxicology Research
Institute/NM
P.O. Box 5890
Albuquerque NM 87185

10 Kent Hancock
EM-352
Quince Orchard, 251
US DOE
Washington DC 20505-0002

3 Kay Hannasch
Ames Laboratory
115 Spedding Hall
Ames IA 50011-3020

3 Ann Heudepohl
Martin Marietta Energy Systems
4-12 WasteMin
P.O. Box 2009
Oak Ridge TN 37831-8180

1 Bob Hill
MMES - Y-12 Plant
Bldg. 9704-2, MS 8010
Oak Ridge TN 37831

1 Jafar Imam
RW-33
Forrestal, 7F-070
US DOE
Washington DC 20505-0002

3 Ken Isakson
Fermilab
Kirk & Pine Streets
P.O. Box 500
Batavia IL 60510

1 P. Josey
Los Alamos National Lab
MS-K572
P.O. Box 1663
Los Alamos NM 87545

2 Karin King
U.S. DOE
Operations Office, San Francisco
7000 East Avenue
P.O. Box 808
MS-L-574
Livermore CA 94550

1 George Klipa
EM-323
Trevion II, 345
US DOE
Washington DC 20505-0002

2 Ray Lang
U.S. DOE
Chicago Operations Office
9800 South Cass Avenue
Bldg. 201
Argonne IL 60439

1 Diane Leek
Tech Reps, Inc.
5000 Marble NE
Albuquerque, NM 87110

1 John Lum
FE-6
Forrestal, 3E-042
US DOE
Washington DC 20505-0002

1 John Marchetti
DP-64
Germantown, C-407
US DOE
Washington DC 20505-0002

6 Robert Meibaum
EG&G/EM
Photo/Video Dept.
P.O. Box 1912
Las Vegas NV 89125

3 Michael Meltzer
LLNL LC-26
P.O. Box 808
Livermore CA 94550

3 Susan Michaud
ORNL/MMES
P.O. Box 2008
Oak Ridge TN 37831-6395

2 Maxcine Miles
U.S. DOE
Operations Office, Savannah River
P.O. Box A
Aiken SC 29808

2 Hilary Noskin
LANL
MS-K572
P.O. Box 1663
Los Alamos NM 87545

2 Dan Ostergaard
BCS Richland, Inc.
Photography & Audiovisual Services
P.O. Box 300
Richland WA 99352-3562

1 Spyros Pavlostathis
Georgia Institute of Technology
School of Civil Engineering
Atlanta GA 30332-0355

1 Dania Pendas
Martin Marietta Spec. Comp.
Pinellas Plant
P.O. Box 2908
Largo FL 34649

1 Jane Powers
EH-231
Forrestal, 7A-085
US DOE
Washington DC 20505-0002

2 Bill Prymak
U.S. DOE
Operations Office, Rocky Flats
Building 116
P.O. Box 928
Golden CO 80402

2 Becky Redeker
Bonneville Power Admin.
P.O. Box 3621 -AJ
Portland OR 97208

2 Bill Reed
Eastman Kodak Company
Commercial and Government Systems
Rochester NY 14653-7128

3 Pat Sallani
WIPP
P.O. Box 3090
Jal Highway
Carlsbad NM 88221

2 Bill Schlosberg
Allied Signal Inc. KC
D/922, SC-8
P.O. Box 419159
Kansas City MO 64141-6159

1 Gary Schmidtke
DOE - Pinellas Area Office
Waste Management
11400 South Belcher Road
Largo FL 34643

3 James Scott
Princeton Univ. Plasma Physics Lab
Forrestal Campus, Receiving 3
US Rt. 1 North
Princeton NJ 08543

1 Pyrtle Seabaugh
EG&G - Mound Plant
Mound Applied Technologies
P.O. Box 3000. OSE-2
Miamisburg, OH 45343-3000

1 Raj Sharma
NE-47
Germantown, F-416A
US DOE
Washington DC 20505-0002

3 Mark Sheppard
EG&G Rocky Flats, Inc.
WMin Prog B130-C
P.O. Box 464
Golden CO 80402-0464

2 Behram Shroff
U.S. DOE
Fernald Operations Office
P.O. Box 398705
Cincinnati OH 45239-8705

2 Rick Slater
NASA/Johnson Space Center
JL-2
NASA Road One
Houston TX 77058

1 Douglas Smith
EM-62
Forrestal, IH-088-22
US DOE
Washington DC 20505-0002

1 J. Stelmach
DOE Grand Junction Project Office
2597 B & 3/4 Road
Grand Junction CO 81503

1 Dan Stoltz
Allied Signal Inc. KCP
Environmental & Health Protection
2000 East 59th St.
Kansas City MO 64141-6159

1 William Tasko
EG&G/EM
Photo/Video Dept.
P.O. Box 1912
Las Vegas NV 89125

3 James Thompson
ITRI
P.O. Box 5890
Albuquerque NM 87119

2 James Thout
Argonne Nat. Lab East
9700 South Cass
Argonne IL 60439

1 J. Thurston
DOE - Amarillo Area Office
Pantex Plant - OS Mgmt. Branch
U.S. Highway 60, FM 2373
Anarukki TX 79120

1 Terry Tyborowski
CR-145
Forrestal, 4A-178
US DOE
Washington DC 20505-0002

1 A. Vollmer
Regul. Oversight & Compl. Supp.
Jacobs Engineering
5301 Central Ave. NE
Albuquerque NM 87108

1 Don Walter
EE-22
Forrestal, 5F-067
US DOE
Washington DC 20505-0002

3 Tom Wantland
Oak Ridge Institute for Science and Education
P.O. Box 117
Oak Ridge TN 37831-0117

3 Shelly Worsham
LBL - Waste Mgmt. Dept.
#1 Cyclotron Rd
MS 875B-101
Berkeley CA 94720

1 G. Todd Wright
Westinghouse Savannah River Co.
Savannah River Site
Aiken SC 29808

INTERNAL:

5	6625	Ted Wheelis, MS 0730
111	6625	Victoria Levin, MS 0730
1	7574	Jim Fish
3	7576	Robyn Davis, MS 1305
10	7613-2	Document Processing for DOE/OSTI, MS 0100
2	8275	Paul Van Dyke, MS 9131
3	8642	Sally Raubfogel, MS 9222
2	8642	Alice Johnson-Duarte, MS 9222
1	8523-2	Central Technical Files, MS 9018
6	12913	Ken Ronquillo, MS 1357
5	7141	Technical Library, MS 9211